AD-A120 111 FOREST PRODUCTS LAB MADISON WI F/G 13/6
FEASIBILITY OF PRODUCING RECONSTITUTED RAILROAD TIES ON A COMME--ETC(U)
SEP 82 R L GEIMER.
UNCLASSIFIED FSRP-FPL-411 NL

END
DATE FILMED
11-82
DTIC

AD A120111

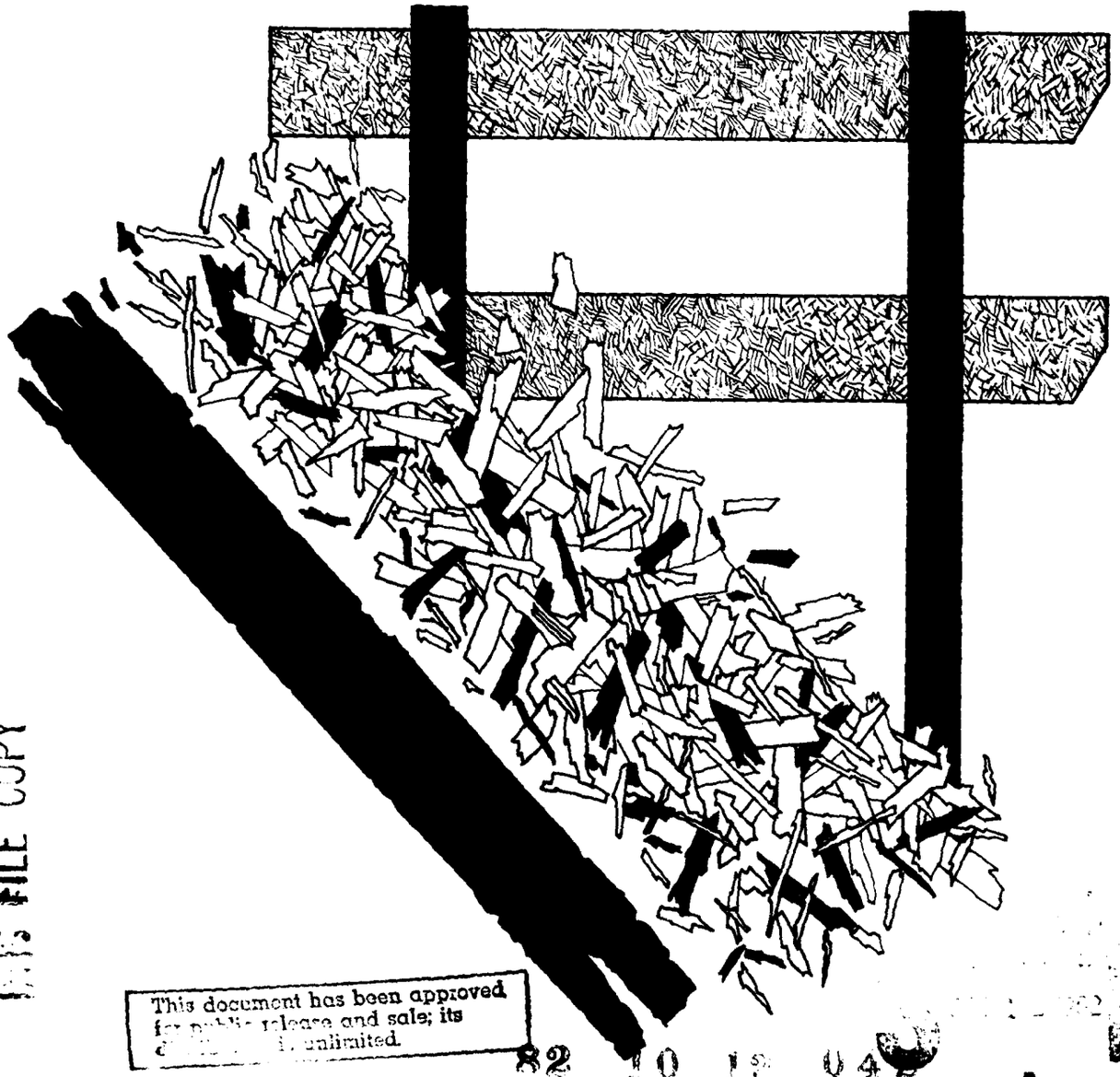
United States
Department of
Agriculture

Forest Service

Forest
Products
Laboratory

Research
Paper
FPL 411

Feasibility of Producing Reconstituted Railroad Ties on a Commercial Scale



DTIC FILE COPY

This document has been approved for public release and sale; its distribution is unlimited.

82 10 12 042

A

Abstract

Research at the Forest Products Laboratory (FPL) has shown that reconstituted laminated railroad ties could be fabricated from old tie material. The described cooperative effort between the Federal Railroad Administration (FRA), the Forest Products Laboratory, and the Potlatch Corporation was undertaken to determine the feasibility of manufacturing ties in a pilot plant operation. Three and one-half tons of material was prepared at the FPL and shipped to the pilot plant where sufficient boards were made to fabricate eleven 7- × 9- × 96-inch ties. Laboratory tests indicated that some of the tie properties were 21 to 32 percent lower then expected. Reduced property values were attributed to ineffective flake alinement and variability in the blending and forming operations. Attainment of target design properties is clearly dependent on the availability of proper fabricating equipment.

United States
Department of
Agriculture

Forest Service

Forest
Products
Laboratory[1]

Research
Paper
FPL 411

September 1982

Feasibility of Producing Reconstituted Railroad Ties on a Commercial Scale

By
ROBERT L. GEIMER, Research Forest Products Technologist

Introduction

United States railroads replace over 20 million ties each year for maintenance purposes. Rising costs and environmental restrictions on disposal have created the incentive to reconstitute new ties from the old ties. Work at the Forest Products Laboratory (FPL) has shown that, with proper technology, high density flakeboards made from old tie material may be laminated into new ties having an effective modulus of elasticity (MOE) of 1.1×10^6 lb/in.^{2} and an average bending strength of 4,500 lb/in.^{2} (*4*).[2] These property levels are estimated to be equivalent to a red oak tie containing near maximum defects as permitted by AREA 645 Chapter 3 (*1*).

Design specifications of the laboratory-made ties called for the outer or face laminations to comprise 40 percent of the total volume of the tie (fig. 1). Face and core materials were obtained by separating 0.040-inch-thick by random width by 2-inch-long ring flakes on a 1/8-inch screen. The larger flakes were used for the face laminations and were alined in the long dimension of the tie. Core boards were formed using a random flake distribution with the remainder of the material which had been screened on a 1/32-inch screen to eliminate very fine material. All layers were 60 lb/ft^3 density (ovendry (OD) mat basis) and contained 5 percent phenolic resin and 1 percent wax.

After the successful completion of the laboratory experiments, the next product development stage leading up to the eventual commercial manufacture of reconstituted ties made from used ties involved the preparation of a relatively large number of full-sized units for "in-track" performance and durability testing. The logistics of preparing material and manufacturing 300 full-size ties, which was the minimum number deemed necessary to give meaningful trial results, was excessive for the facilities at the FPL. Consequently, pilot plant facilities located at Lewiston, Idaho, which contained the special flake alinement equipment necessary to make the outer laminations of the ties, were made available by the Potlatch Corporation. A cooperative research effort, limited in scope to the fabrication of 11 ties, was arranged between FPL and Potlatch to determine the feasibility of producing a larger quantity of reconstituted ties at the pilot plant. The work was funded by the Federal Railroad Administration (FRA). Conversion of the old ties first into chips and then into flakes was accomplished at the FPL. Subsequent processing of these flakes into boards and lamination of the boards into ties was completed at the Lewiston plant. Performance tests on the finished product were performed at the FPL.

This report describes material preparation, manufacturing procedures, and test results for 11 full-size ties made at the Potlatch pilot plant, Lewiston, Idaho.

---

[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[2] Italicized numbers in parentheses refer to literature cited at end of report.

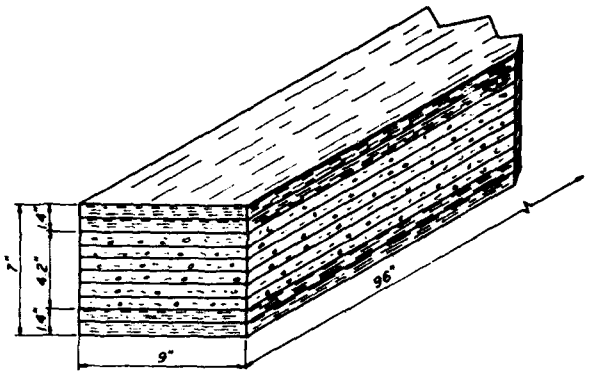


Figure 1.—Laminated reconstituted railroad tie uses aligned flakes in the face layers.

(M151-103)

Figure 2.—Old railroad ties being unloaded at the Forest Products Laboratory.

(M144284-7)

Material Preparation

Chipping and Flaking

All of the material, approximately 7,350 pounds (at 35 pct moisture content (MC), based on OD wood), used in the trial was prepared at the FPL. Discarded red oak ties were unloaded from railroad gondolas, manually scraped to remove surface dirt, and cut into 12-inch blocks (figs. 2-4). The length of the block was limited by the throat of the laboratory-size machine used to convert the ties to chips. Numerous spikes and an occasional rail plate were still attached to the ties. No attempt was made to utilize the rail seat portion of the tie.

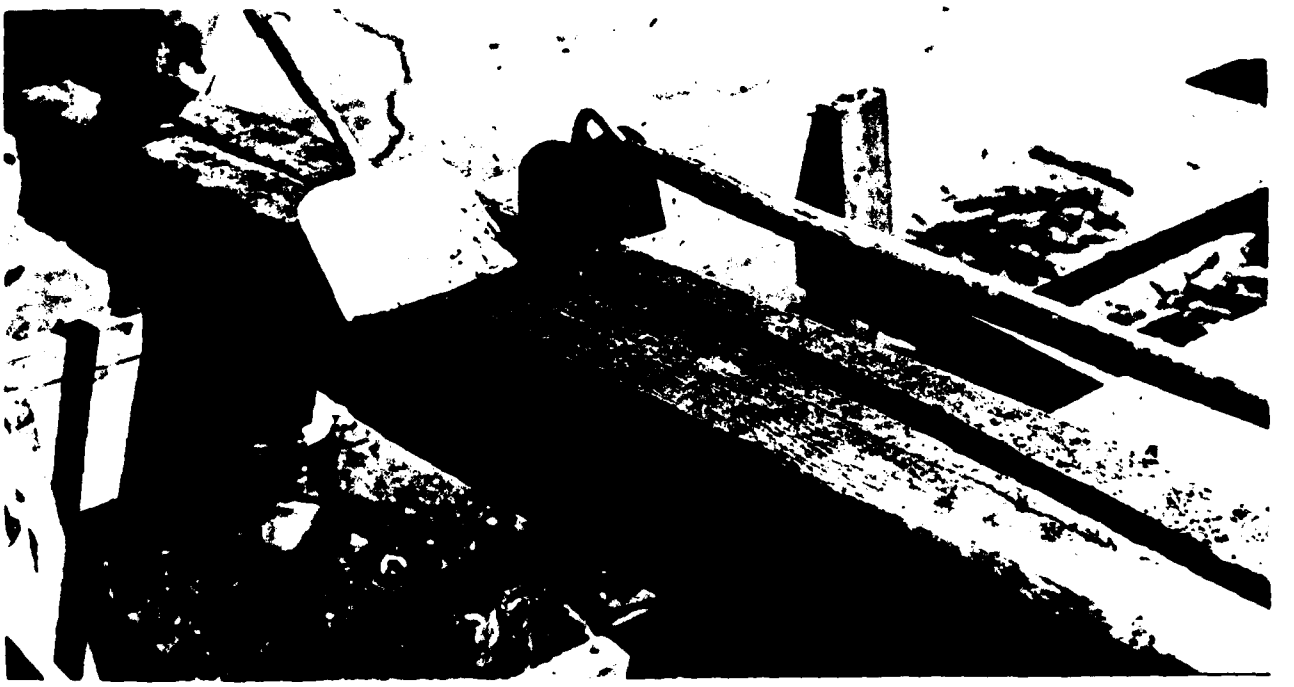


Figure 3.—Ties were scraped to remove exterior contaminates. *(M145819-6)*

Figure 4.—Stones and dirt remained imbedded in 12-inch-long blocks ready for chipping.

(M145820-3)

Preliminary scraping and washing failed to remove all of the grit and stones which were imbedded in deep splits and cracks in the ties (fig. 4). The knives in the chipper, however, were not affected to a major degree by the contaminant. This machine has a series of 2-1/2-inch-long knives staggered around and across the peripheral surface of a 40-inch-diameter rotating drum. The heavy shock load produced on the wood block as each knife takes its cut may have helped to dislodge the stones.

After the blocks had been cut to large maxi chips (fig. 5), the material was loaded into a mesh basket holding about 150 pounds and washed in a tank by succes-

Figure 5.—Large "maxi" chips cut from old railroad ties.

(M146442-1)

sively submerging and removing the basket. This method proved to be only partially effective as evidenced in damage sustained by one set of knives used to convert the chips into flakes. It is believed that a vibrating-type washing conveyor, capable of separating heavy material, would have been much more effective in removing the stones. Flaking was done in a 36- inch-diameter ring-type flaker with knives set at 0.038 inch.

Drying

Moisture content of the old ties varied considerably both within and between ties, depending on their environmental exposure history. The ties used in this study contained approximately 15 percent MC in the outer 2-inch-thick shell and 25 percent MC in the inner core. Washing the chips increased the overall MC. To manufacture flakeboard at 60 lb/ft³ density, MC of the furnish must be decreased initially to a level of 4 percent or less.

Flakes were dried in a 4-foot-diameter rotary drum-type batch dryer capable of holding approximately 300 pounds (OD basis) of material. In this dryer the majority of the air is recycled past the steam coil heat exchanger. Initial drying temperature was 210° F. The temperature rose to 220° F as the MC of the flakes decreased to 8 percent and had increased further to 230° F when the flakes were removed at a moisture content of 4 percent. Creosote fume emission was very noticeable when the furnish MC dropped below 8 percent, and increased when the material reached the higher temperatures.

The actual MC of the flakes is somewhat questionable as the same creosote emissions occurring during drying also take place as the MC samples are reduced to zero percent in the laboratory meter.

To determine the relationship between meter readings and actual MC, creosote and water analysis tests were made on material which had been dried to various levels. To provide for greater uniformity in the test, a quantity of flakes were hammermilled through a 1/8-inch screen. Following conditioning at 90 percent relative humidity (RH) and ambient temperature, approximately 18 percent MC, the material was dried in an oven at 205°F. Moisture content samples were progressively taken during the drying period along with representative samples to be analyzed for creosote and water. The procedure was repeated with another batch of material at a drying temperature of 260° F. With few exceptions, the moisture meter indicated a level 1 percent lower than that determined by the chemical analysis method (fig. 6). This is the reverse of what is expected and can be attributed to the short 5-minute dwell time in the meter. The results indicate, however, that the moisture meter can be used to estimate MC within the normally wide confidence limits established by variability within the material.

Results of the creosote analysis were somewhat variable but confirmed that creosote emission does

occur sooner at the higher drying temperatures (fig. 7). Creosote content at the end of the drying period was between 5 and 7 percent.

Screen Separation

Following drying, the material was classified into face, core, and fines portions. Flakes retained on a 1/8-inch screen were used to manufacture the surface laminations of the tie, while that portion passing through the 1/8-inch screen but retained on a 1/32-inch screen was used for the core boards. The fines passing the 1/32-inch screen were discarded. Classification is shown in table 1. The screening segregated the material into usable fractions very closely approaching the construction design of 40/60 face-core ratio. Utilization of the tie plate sections, which contain 25 percent of the original tie volume, will be dependent on the development of a primary chipping or crushing machine which is not harmed by the presence of metal contaminates. This type of primary breakdown will likely produce more fines and change the ratio of available face and core material.

Manufacturing Procedures

The furnish material was shipped in large plastic bags to the Lewiston pilot plant for board fabrication. Blending of 5 percent liquid phenolic resin and 1 percent wax was accomplished in a rotating drum continuous-type blender. The phenolic resin used in this trial was supplied by a different company than that which was used previously to manufacture laboratory boards (*4*). The core material was formed by hand into 23- × 102-inch mats. Two of these mats were pressed at the same time. The face flakes were formed into 54- × 102-inch mats using the in-plant forming machine and alining equipment. Mats were trimmed to a 46-inch width prior to being pressed. The oak ring-cut face flakes had a bulk density of 10.5 lb/ft³, much higher than the softwood disk flakes for which the alinement machine was designed. This resulted in poor flake alinement which, as indicated later, proved to be a factor in reducing tie performance. The maximum board pressure obtained with the press was 553 lb/in.². This caused difficulty in obtaining controlled press closure with a 60 lb/ft³ board. No thickness gage bars were used. A typical time/pressure/temperature relation occurring during the pressing cycle is shown in figure 8. Pressure was reduced to 100 lb/in.² on the board after 7 minutes. Initial platen temperature was 350° F. Centerline core temperature reached a maximum of 250° F at the end of the cycle. Steam was turned off after 4.5 minutes and cold water was introduced into the platens. Cooling was necessary to prevent the 60 lb/ft³ boards from blowing when the press was opened, and required a 20-minute press cycle.

After pressing, the panels were cooled, cut into 9- × 96-inch boards and sanded. Considerable thickness and density variation existed within and between the panels. This was due to nonuniform mat formation, uneven press platens, lack of gage bars, and cooling the press

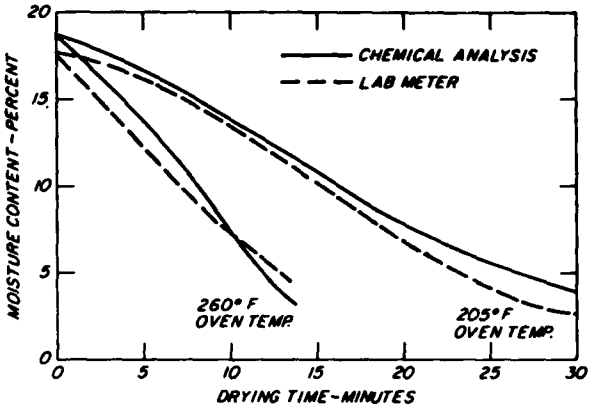


Figure 6.—Moisture content of creosoted railroad tie particles as measured by a laboratory moisture meter and a chemical analysis for creosote and water.

(M151-104)

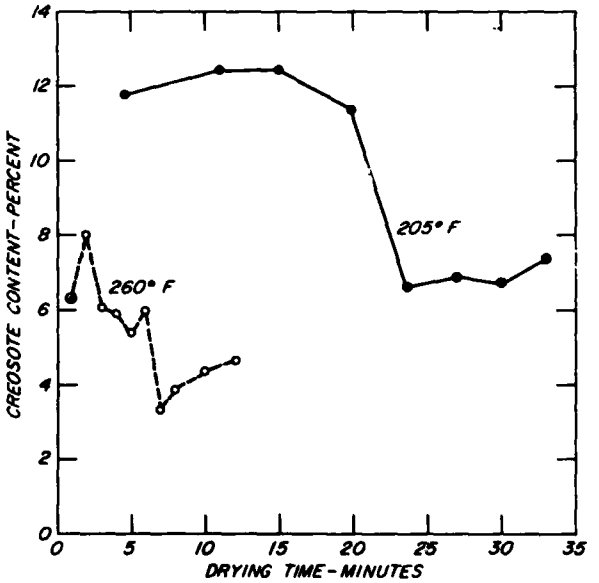


Figure 7.—Effect of drying time and temperature on creosote content of railroad tie particles.

(M)151-105)

Table 1.—Classification of railroad tie flakes

Portion	Percent of total	Percent of usable
Lost in processing	2	—
Face (+ 1/8-in. screen)	35	38.9
Core (-1/8, + 1/32-in. screen)	55	61.1
Fines (-1/32-in. screen)	8	—

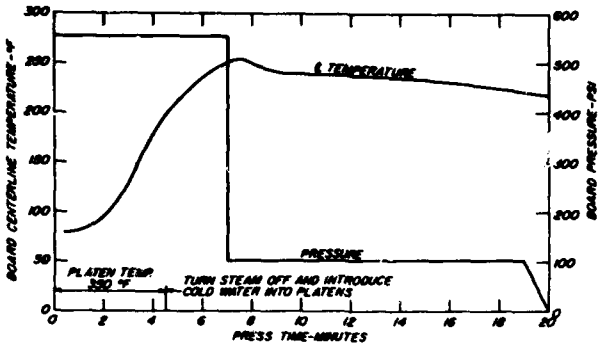


Figure 8.—Press cycle used to reconstitute 60-pound per cubic foot flakeboards from old railroad tie material showing the variables of centerline "core" temperature and board pressure.

(M151-106)

from one end. Each board was sanded to a maximum thickness which permitted removal of within panel variations. The boards were then matched in such a manner so as to provide a total tie thickness of approximately 7 inches. Seven ties had face layers which approached the target thickness of 40 percent while the remaining four ties had face layers of approximately 26 percent. The boards were laminated into finished ties using a 60-pound per thousand square foot single glueline of cold-set catalyzed phenol-resorcinol resin. Ties were pressed in a cold press overnight.

Testing

Bending and Shear

All 11 ties were tested nondestructively for bending stiffness in accordance with ASTM D 198-67 (2) using third point loading on a 90-inch span. Five of the ties were tested to destruction to determine modulus of rupture. Pieces of the broken ties were tested to determine the shear strength of the laminated glueline. Results are presented in table 2. Modulus of elasticity of the first seven ties shown in table 2 (approximately 40 percent face layers) averaged 889 × 10^3 lb/in.^{2}.

The effective MOE (E′) of a three-layer composite can be predicted from the following equation:

$$E' = E_f\left(1 - \frac{t_c^3}{d}\right) + E_c\left(\frac{t_c^3}{d}\right) \qquad (1)$$

where E_f = MOE of the face layers—lb/in.^{2}
E_c = MOE of the core layer—lb/in.^{2}
t_c = Core layer thickness—inches
d = Total thickness—inches

For a section 7 inches thick having 60 percent of its thickness in core material, equation (1) reduces to:

$$E' = E_f(.784) + E_c(.216) \qquad (2)$$

Figure 9 shows different levels of effective MOE (E′) for various combinations of E_f and E_c. Nondestructive testing of the individual panels prior to their being laminated into ties showed that core panel MOE averaged 635 × 10^3 lb/in.^{2} and face panel MOE averaged 8.78 × 10^3 lb/in.^{2}. The theoretical effective MOE of a 7-inch-

Table 2.—Properties of pilot plant manufactured reconstituted laminated railway ties

Tie No.	Number of face laminates	Percent face	Tie thickness	Specific gravity	Modulus of elasticity	Modulus of rupture	Glueline[1] shear
			In.		K lb/in.^{2}	Lb/in.^{2}	Lb/in.^{2}
2-3	4	41.5	6.98	1.031	834	—	—
3-3	4	41.5	6.98	1.046	874	2840	880
1-1	4	40	7.02	1.025	899	—	—
3-2	4	40	7.02	1.043	865	3000	879
3-1	4	38	7.04	1.053	938	—	—
1-4	4	38	7.00	1.040	916	3290	1030
1-2	4	38	7.00	1.003	866	—	—
1-3	2	26.5	6.98	1.055	741	2380	717
2-1	2	26	7.03	0.995	699	—	—
2-2	2	26	7.01	1.032	719	—	—
2-4	2	26	7.01	1.014	715	2340	692

[1] Average of 12 samples.

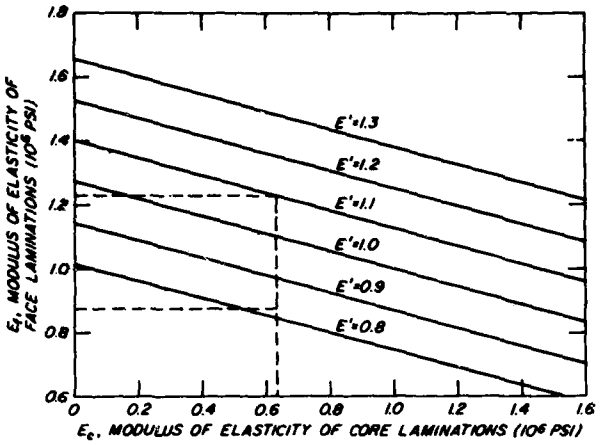


Figure 9.—The effective modulus of elasticity (E') of laminated crossties is dependent on the elastic moduli of outer and inner laminations.

(M151-107)

thick tie with 60 percent of its total thickness in core material and having face and core properties as defined above is 825 × 10^3 lb/in.² (see dashed line, fig. 9).

The reason for the low effective MOE's of the ties as compared to the design value of 1,100 × 10^3 lb/in.² is attributed to the relatively low MOE of the face layers caused by poor flake alinement. In order to attain the target MOE of 1,100 × 10^3 lb/in.² with core material having the properties defined above, the face layer MOE must be increased to approximately 1,230 × 10^3 (fig. 9).

Three of the ties having face layers approximating the 40 percent design thickness were tested to destruction. Modulus of rupture averaged 3,043 lb/in.² or 68 percent of the target value. One of the ties failed in interlaminar shear. Failure occurred in the board stratum, not in the laminate glueline, and indicates either low density or poor flake bonding.

Glueline shear tests were conducted in accordance with ASTM D 1037-72 procedures (*3*). Average values are equal to or better than the same property as measured previously on laboratory-made ties (table 2).

Dimensional Stability

Due to the size and nature of the product, normal dimensional stability tests were not applicable. Sections of ties 7 × 9 × 12 inches were exposed to a cyclic test consisting of 1/2 hour vacuum under water (25 in. Hg), 1 hour pressure under water (60 lb/in.²), 1/2 hour vacuum under water and 21 hours pressure under water. After measuring the swelling, the samples were dried at 240° F until they reached initial weight (approximately 48 hours). This procedure was repeated six times. Ties made previously in the laboratory swelled approximately 19 percent during the first cycle and reached a final thickness of 35 to 40 percent above the initial 7-inch thickness after six cycles. Ties made in the pilot plant swelled as much as 35 percent after the first soaking. Thickness increased in the same samples to as much as 64 percent after the first drying and 77 percent after the second soaking. Delamination prevented continuation of the test (fig. 10). Adverse reaction of the ties to this cyclic test indicates poor bonding and can be attributed to either a difference in the resin type used, insufficient resin cure, or inefficient resin application.

Conclusions

Processing of the tie plate section (amounting to 25 percent of a railway tie) will necessitate development of equipment capable of handling metal contaminates. No major difficulties should be encountered in preparing flakes from the remainder of the tie provided great care is used in cleaning and washing the furnish of which 10 percent is lost in processing. The remaining usable portion can be sorted on a 1/8-inch screen to produce the 40/60 percent face-core ratio used in the present tie design.

Creosote fume emission occurs when flakes are dried below 8 percent MC. Fume emission increases at drying temperatures above 205° F. Commercially available moisture meters can be used to approximate the MC of creosoted flakes to within 2 percent of actual MC.

Chemical analysis to determine the extent of creosote reflects the initial variable distribution of the creosote in the furnish. Creosote retention after drying of the

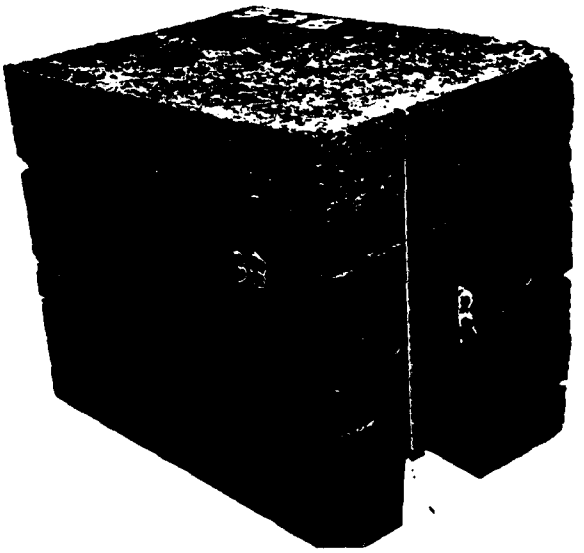


Figure 10.—Thickness swelling during a cyclic vacuum-pressure-soak/drying treatment caused delamination of the samples.

(M147207-10)

flakes to 4 percent MC averaged 6 percent in this trial and is in line with the previous work showing a 10 percent creosote content in the outer shell and 5.5 percent creosote in the inner core of the old ties.

Bending stiffness and strengths of the pilot plant ties were 21 and 32 percent lower, respectively, than those same properties of laboratory-made ties. Lower bending properties are attributed primarily to poor flake alinement but may also have been affected by inefficient glue distribution and variability in mat density. Glueline shear strengths were comparable to those ties laminated in the laboratory. Specimens failed to withstand two cycles of a vacuum-pressure-soak drying cycle, indicating the need for improvement in adhesive application.

The trial indicates the feasibility of producing new reconstituted railway ties from old ties. Attainment of present target design properties on a commercial scale, however, is clearly dependent on the availability of equipment and processes capable of providing uniform adhesive distribution, uniform mat density, and an adequate level of flake alinement.

Literature Cited

1. American Railway Engineering Association. 1974. Ties and wood preservation. AREA Bull. 75(645):379-464. AREA, 59 East Van Buren St., Chicago, Ill. 60605.

2. American Society for Testing and Materials. 1967. Standard methods of static tests of timbers in structural sizes. ASTM D 198-67, Philadelphia, Pa.

3. American Society for Testing and Materials. 1972. Standard methods of evaluating the properties of wood-base fiber and particle panel materials. ASTM D 1037-72, Philadelphia, Pa.

4. Heebink, B. G., M. J. Superfesky, R. L. Geimer, and J. Chern. 1977. Recycling the wood crosstie: Researchers develop and test laminated particle tie. Railway Tract and Structures 73(7):26-31, July.

DTIC COPY INSPECTED 2

Accession For
NTIS GRA&I
DTIC TAB
Unannounced
Justification
Distribution/
Availability Codes
Dist | Avail and/or Special
A

L2, WU24, RE2

U.S. Forest Products Laboratory

Feasibility of Producing Reconstituted Railroad Ties on a Commercial Scale, by Robert L. Geimer, Madison, Wis., FPL 1982.

8 p. (USDA For. Serv. Res. Pap. FPL 411).

Research has shown that reconstituted laminated railroad ties could be fabricated from old tie material. This report describes the material preparation, manufacturing procedures, and test results for 11 full-size ties made at a pilot plant.